Opening Activities

This section of the Guide summarizes what the *Passport to Knowledge* development team considers the most significant Content or Curriculum objectives for *Live from the Hubble Space Telescope*. For convenience and clarity, they are grouped by Opening and Closing Activities, and by Video program. However achieving these objectives will likely involve on-line as well as video and hands-on work.

While *LHST* is *not* intended as a plug-in replacement for sections of your existing course of instruction, we do believe this 3-5 week project can be justified in terms of at least three criteria: (1) what **content** your students know after participating which they might not have known before; (2) what positive **attitudes** they develop towards what they now know; and (3) what research and technical **skills** they gain and practice (see also pp. 10–11 for thoughts on *PTK* and science reform, and, of course, the Teacher and Student Evaluation pages.) Each individual Activity also states a specific Instructional Objective in clear-cut performance or behavioral terms.

We hope these project objectives and program overviews also provide you with tools to create an "anticipatory set" for your students, so that they approach each Activity or viewing experience as active learners rather than passive consumers.

Project Objectives

After Program 1 and Activities 1A-1C, students will be able to:

- describe the scale and structure of the solar system in terms of distances between the planets, compare/contrast their relative sizes and distinctive characteristics, and differentiate between "terrestrial" and gaseous bodies.
- develop collaborative learning and research skills to create multimedia reports illustrating the complexity and diversity of our solar system.

After Program 2 and Activities 2A-2E, students will be able to:

- describe the Hubble Space Telescope as both a spacecraft AND a telescope, and compare and contrast the importance of each role.
- describe the extensive network of people, places and processes needed to design, deploy and operate the HST.
- summarize current knowledge about Neptune, Pluto and Jupiter, and explain what might be learned about these planets through the use of HST during the *Passport to Knowledge* observations.
- identify the main parts of the electromagnetic spectrum, and compare and contrast the use of various wavelengths to study the planets.
- compare/contrast HST with other telescopes, and describe how its unique advantages are being used during the *Passport to Knowledge* observations.
- describe how HST observes the "moving targets" of the planets of our solar system, and how the data is routed down to Earth for analysis.

After Program 3 and Activities 3A-3D, students will be able to:

- understand how images are constructed from digital data, and the process by which black and white images become color pictures.
- understand how the use of different color filters, time exposures and image processing techniques reveal different aspects of the same image.
- compare/contrast weather patterns on the HST target planets to storms on Earth, in terms of scale, speed of motion, vertical structure and duration.
- describe how scientists gather data, interpret it, test hypotheses, come to preliminary conclusions and publish results for review by peers.

After Closing Activities 4A-4C, students will be able to:

- synthesize and articulate, in media of their own choice, the individual learning they have experienced during *Live from the Hubble Space Telescope*.
- discuss/debate the value to society of such "Big Science" projects as HST.
- describe and evaluate the effects of advanced technology on the process of contemporary scientific research.
- demonstrate a greater interest in the study of astronomy, and a more positive attitude towards scientific research and/or high-tech employment as a possible career.

Program 1:
The Great Planet Debate

Aired November 9, 1995, and available on tape from NASA CORE, (see inside front cover). The full script of this program may be found on-line.

This 30 minute program introduced the entire project, and announced the on-line discussion which led to a December 1995 consensus decision about which planets to observe. The four astronomers who served as "Planet Advocates" for the on-line debate (Reta Beebe for Jupiter, Marc Buie for Pluto, Heidi Hammel for Neptune and Carolyn Porco for Uranus) each presented reasons for using three HST orbits for "their" planet, and summarized key scientific goals which could be achieved. Presenter Bill Gutsch reviewed the history of Space Telescope (launch, servicing mission, most revealing and amazing images, current capabilities). Gutsch provided a project timeline, Internet addresses for on-line updates and encouraged participation in an unprecedented experiment in science education and outreach.

Activity 1A: Planet Tours, Inc.

Objective

To collaborate in teams and demonstrate the ability to use appropriate research, writing and presentation skills to create a fact-based travel brochure or poster for an exotic location elsewhere in our solar system.

Engage

Ask students to describe their favorite summer vacation. Take out a map of your state, America or another country, and have students place pins to show where they've traveled. Ask them what made their adventure special, and what features of the location they most remember. Ask them where they'd like to go if they could go anywhere in the world. Ask them where they'd like to go if they could go anywhere in the solar system!

Explore / Explain

Explain to students that for this Activity, they are going to imagine that it's not 1996 but rather far in the future. Tourist travel to the planets is just becoming possible and they are working for the first interplanetary travel agency, "Planet Tours, Inc." Their task is to research the wonders of the solar system (especially those of the *LHST* target planets) and create a series of brochures or travel posters designed to attract the first space tourists.

Materials:

- Advertisements from Sunday newspapers or travel magazines, and/or brochures and posters collected from area travel agencies
- appropriate art supplies, texts, back issues of astronomy and science magazines with space imagery, or computers with scanners and graphics software

Procedure: Divide the class into conveniently-sized teams, who will each work on a different solar system destination. Have students collect brochures, travel posters and other material advertising exotic destinations. Challenge them to create similar brochures and travel posters for the most exotic ports of call in the solar system. What wonders of Mercury or Mars do they feel would be most appealing? What adventures for the well-equipped adventurer—ballooning on Jupiter? Sulfur-surfing on Io? What creature comforts required to tame the chill of Mars, the heat of Venus? What incredible sights on Neptune or Pluto, Triton or Charon?

Have student teams discuss what factors make some posters and brochures more compelling than others. How is the writing they find in a travel brochure different from what they find in a book, the front page of a newspaper, or a magazine? Have students develop a list of "rules" for a successful travel poster or brochure

Turn students' attention skyward. Help students research the necessary factual information about our neighboring worlds and obtain the pictures they need from books, magazines, CD-ROMs or the Internet. (Check our Web page for links to some great on-line resources. See Activity 4B for tips on how to make slides from books or computer screen.) Challenge them to find the most exciting sites and sights offered by their chosen planet or its moons—from *Valles Marineris*, a Grand Canyon on Mars that would stretch across the entire United States, to sheer cliffs of ice on Uranus' satellite, Miranda, 8 miles high. What resort attractions might 21st century technology bring? A golf course on the moon? Snow machines creating a long downhill ski run from a mighty Martian volcano?

Have students make rough sketches of their posters or brochures. Through team discussion, encourage them to edit and refine. Have them compose the finished product before making an oral presentation to the entire class—and come prepared to respond to charges of false advertising or bad science!

A note from Jan Wee, Education Outreach Coordinator, *Passport to Knowledge*

Dear Educators,

Welcome to *Passport to Knowledge!* One of my top priorities is to provide support to all educators as you integrate our projects into your learning environment. My background of 18 years as science teacher, computer support services (especially in the area of Internet-based resources), library media director, and *Passport to Knowledge* team member gives me a broad perspective.

Please feel free to call, no matter your question (608-786-2767), or fax (608-786-1819), or e-mail (janw@quest.arc.nasa.gov), or write (Jan Wee, 431 North Youlon Street, West Salem, WI 54669).

Looking forward to assisting your efforts to make this experience an exceptional and successful one!

Expand

Lead a class discussion about what might some day be feasible, and what are likely to remain fantasies. (Be somewhat cautious about skepticism: in the late 19th century, eminent scientists were still saying heavier-than-air flight was utterly impossible.)

Give students an overall advertising budget for "Planet Tours, Inc." for a one month advertising campaign, and challenge students to develop a marketing plan. If a student has a relative who's a travel or advertising professional, they might be invited to give a talk before the class.

Have them make their presentations to another class (perhaps a lower grade, who can then also ask questions, turning your students into teachers) who will vote on their favorite planetary vacation destination.

Activity 1B: Painting Planets

Objective

Students will research and construct accurately-scaled models of the planets, reflecting each planet's currently-known physical characteristics and appearance.

Engage

Ask your students to close their eyes. Have several students describe the planets of our solar system. Challenge them to recall as much detail as possible. Ask other students to describe the sizes of the various planets relative to each other.

Explore / Explain

Explain that you are going to explore our solar system by creating visually-accurate scale models of all the planets, depicting currently known features.

Materials

- appropriately-sized spheres or balls, obtained from craft stores, art supply houses or other sources (hint: with the Coach's permission, search the gym for punctured sports equipment of the right relative dimensions: see chart)
- paints (and brushes) or other coloring tools (one teacher suggests covering the balls with masking tape, then using colored markers rather than paint)
- sheets of clear plastic, paper plates or sheets of stiff cardboard (to serve as planetary rings for the 4 planets that have rings)
- ruler or measuring tape, paper, marking pens

Procedure Divide the class into teams of 2-3 students, and have each team choose a planet to create. Copy and distribute Table 1B-1 as a reference for the actual sizes of the planets and to corresponding sizes (in inches or cm). Help students determine the relative size of their planet so that everyone is working on the same scale. If they are going to show the ring systems, supply Table 1B-2. Once students agree on the planets' sizes, assign each team the task of acquiring an object of the right dimension.

Have students research the appearance of each of the planets using books, magazines, CD-ROMs, Internet pages or other sources (see Resources for suggestions.) Challenge students to identify the most important surface or atmospheric characteristics of each planet, and to think about ways in which these features can be represented on their models.

As they research their planet, have them list its special characteristics, as an Artist's Think Pad, recording its color or colors, surface or atmospheric features, whether it has rings and, if so, whether they are light or dark? Have students use this as a guide to decide what coloring or painting techniques they'll need to use to create their model. How will they construct and assemble the giant planets' ring systems? (Remember Neptune's strange ring arcs: for more, see *LHST* Program 1.) If you're not sure about colors and textures, consult with an art teacher or art supply store. Consider whether larger planets need more student artists and let the painting begin.

When all the models have been painted, discuss where they can be displayed: the ceiling of the classroom, a school hallway or the auditorium. A special assembly, with students reporting on the completed *Live from the Hubble Space Telescope* project could be scheduled. Have students make a sign for each planet listing its name, size and other key data (see Activity 1C).

If you want to add the Sun to your solar system model, how big a ball would you use? (The Sun is 865,000 miles [1,392,000 kilometers] in diameter, about 109 times the diameter of Earth.) Have students research whether there's a ball or sphere around your school that's large enough. Could they paint a picture of the Sun this large to go with their planets? How big would it be? Where would you place it?

Dr. Marc Buie on Pluto Lowell Observatory, Flagstaff, AZ,

In 1988, Pluto passed perihelion, which is the point at which it's closest to the Sun, and it's going to begin its 125 year voyage to its most distant place in its orbit. And over this time Pluto is going to receive less and less sunlight, and cool off, so we now have an opportunity to study Pluto when it is at its warmest. If we don't take the opportunity now to make these observations we'll have to wait another 240 years to repeat the experiment.

Pluto is sort of the last "astronomers' planet." We haven't yet had a close-up view with a spacecraft. We have an opportunity here to see the development of a science and a knowledge-base about Pluto in our lifetimes. And certainly the past ten years have been exciting, watching what we learned about Pluto. I am certain we are going to learn a great deal more, but this is sort of the special epoch in human history where we are learning for the first time what this planet is all about.

Expand

As a math activity, using ratios and proportions, have older students calculate the planets' relative sizes, defining Jupiter (instead of Earth, as in the table below) as 1 inch, and all other planets scaled accordingly.

If resources permit, (and the drama department or tech crew has some stage lighting to loan!) students may wish to light their planet models dramatically in a darkened room and video tape "close encounters" with their planet, as if their video camera were a spacecraft like the twin Voyagers, or Galileo, slowly flying past. (See *LHST* Program 1, "The Great Planet Debate" for JPL's great computer graphics representations of the Voyagers' encounters with Jupiter, Neptune and Uranus. Remember Galileo will be orbiting Jupiter and its moons for the next 2 years.) Students may later wish to edit these sequences into a multimedia presentation as described in Activity 4B, p. 39.

As another math expansion, challenge students to calculate how far apart the planets would have to be from each other given the size scale of the planets that they adopted. Use the table of distances provided in Activity 1C, p. 16 Whether you use that Activity or not, they'll soon see that our solar system is a very large and empty place!

At the conclusion of *Live from the Hubble Space Telescope*, have students revisit their models of the planets we'll be studying (Neptune, Pluto and Jupiter) and see what "new" information they now have. As a writing activity, how would they update the textbooks or other sources they consulted? Perhaps you might even submit their reports to your text publisher as input for their next revision! (see also Activites 4B and 4C pp. 39–40)

Have students keep a journal as they create their model. What did they do, and discover, each day? What were the easiest, most fun parts of the project? What parts were more difficult or challenging? If another class were going to do this same project next year, what pointers would they give them? Consider keeping a photo-journal or video diary of their progress. Taking a picture of their model each day would provide a timelapse record of how it gradually changed into a planet. Paste such pictures into their journal entries for each day: think how in years to come, you'll also be able to paste video into your students' Web pages!

TABLE 1B-1 SIZE OF PLANETS

Planet	Diameter in Miles	Diameter in Kilometers	If Earth was 1 inch (cm)
Mercury	3,032	4,878	0.38 (a little more than 1/3)
Venus	7,523	12,104	0.95 (about like Earth)
Earth	7,928	12,756	1.00
Mars	4,218	6,787	0.53 (about 1/2 Earth)
Jupiter	88,863	142,980	11.2
Saturn	74,916	120,540	9.5
Uranus	31,771	51,120	4.0
Neptune	30,783	49,530	3.9 (about like Uranus)
Pluto	1,430	2,300	0.18 (about 1/2 Mercury)

TABLE 1B-2 SIZE OF RINGS

Planet	Diameter of Rings if Earth is 1 inch (cm) Inner Edge	Outer Edge
Jupiter	9.6	10.1
Saturn	11.6	21.4
Uranus	6.6	8.1
Neptune	8.9	11.0

PROF HEIDI HAMMEL, on Neptune Massachusetts Institute of Technology

What I like best about the planet Neptune is that every time you look at it, it's different. So Neptune can be your planet…No one else will have seen the clouds that you see and they'll probably never be seen again. And so that means that the pictures of Neptune your students take will be absolutely unique…

One of the biggest surprises when the Voyager spacecraft flew by Neptune was a huge dark spot on the planet. We called it the "Great Dark Spot." We weren't able to see it from Earth because Neptune is the most distant planet from us right now. When we looked with the Hubble Space Telescope last year that Great Dark Spot was gone! It had simply disappeared, it wasn't there anymore, which was a big surprise but when we looked very, very carefully, we saw a different big, dark spot on the planet, in the northern part of the planet— the other one was in the South—so that means Neptune's atmosphere just turned upside down!

When we look at Neptune this time we don't know what we are going to see. There might be a whole, new dark spot and that dark spot would belong to this (PTK) group. They would have discovered it!

Objective

Students will demonstrate the ability to convert distance data into a large-scale model of the solar system (using the "Astronomical Unit" as a yardstick) with students representing the planets.

Engage

Ask students to describe how the previous activity helped them understand the relative sizes of the planets. Tell them they haven't seen anything yet. Now they are going to calculate and show just how far apart they are.

Materials

- 10 white poster boards (Approximately 2 x 3 feet in size)
- thick black marking pen
- piece of brightly colored yarn, rope (corresponding to the length of your "A.U." (see below).

Explore / Explain

Tell students that they are going to measure distances to the various planets, and that some of them will "become" the planets, in an accurately-scaled representation of their correct distance from the Sun. Pass out copies of Table 1C, but cover the numbers in the last column before making copies. Point out the distances in miles or kilometers: ask them if they have their walking shoes ready!

Procedure Explain that to build this model, the class will have to scale down the distances involved, to numbers that can be dealt with easily. Look at Table 1C with them. Point out that if we try to deal with distances to planets in either miles and kilometers, we have to work with huge numbers. (Ask them if we could talk about distances to major cities around the world in inches? Ask them why we don't.) With this in mind, introduce them to a useful new unit of distance, the Astronomical Unit, which is the distance of the Earth from the Sun, just under 93 million miles or 150 million kilometers. This will become our new "yardstick." As a math exercise, have them calculate the distances from the Sun to all the planets in A.U.s, and then confirm their answers with the right-hand column of numbers in the table. Next, have them calculate the distance in A.U.s of each planet from its neighbor. Point out that now, when representing the solar system, instead of dealing with numbers in the hundreds of millions, we only have to worry about numbers up to about 40, at most.

Brainstorm where the class will create its Great Student Solar System. (Hint: Pick a space long enough to be impressive, and fun like a playground or athletic field.) Next, choose a reasonable length for the A.U. in your model. (Hint: Pre-measure the total length of the area likely to be selected for the model and divide this length by 40. This will mean that if the Sun is at one end of the space, Pluto will just neatly fit at the other, with all the other planets spaced out [sic] in between.)

Let students choose to be the different planets and the Sun. If you are preparing this Activity one day and making the model the next, suggest that they wear clothing appropriately-colored for their celestial object. (Mars is a nice, fashionable, rust-color, but Jupiter might require something tie-dyed.)

Discuss having more than one student be each planet, with the number of students indicating the relative size of the planet (see Activity 1B) Have students make posters with the names of their celestial object in large letters, with a picture, created by them, or found in a magazine (being sure only to use ones that are ok to cannibalize!)

The Gallery of the Sky

What is this gallery of the sky?
Images placed there by the gods,
like a pattern,
A pattern of diamonds spread
on a table,
A pattern of pins stuck in black cloth,
Memories,
Memories of forgotten heroes,
Memories of forgotten times,
An art book of love,
that soothes the soul,
An art book of hope,
to help us through it all.
A gallery,
A gallery of everything and
nothing at all

EMILY BERNSTEIN, Summit Middle School

To construct your model, go to the designated place with students, posters, and the piece of brightly-colored yarn cut to the length of A.U. chosen for your model. Start at the Sun and place that student in position. Select two or three students as Official Solar System Measurers (OSSMs). With A.U. yarn in hand, have them measure off the correct distance to each planet, using the numbers they have calculated. As the OSSMs reach the right position for each planet, have the student who will represent that planet take their place until the whole solar system is complete. Then, take a few pictures of your Great Human Solar System Model and return to class for discussion. (*Live from the Stratosphere*, Program 5, contains a similar Activity, presented by HST Guide author Bill Gutsch, done live on-camera at NASA Ames in an aircraft hangar: it might help to review that tape if you have it.)

See also Carl Sagan's *Pale Blue Dot* for a discussion of how when Voyager left our solar system, beyond the orbit of Neptune, it turned to take a farewell snapshot which emphasized just how small our Earth was against the huge dimensions of our solar system: think about doing something rather similar, looking out from the Sun to distant Pluto, and vice versa.

When the students reassemble, discuss what they discovered about how the planets were spaced. Most will probably be surprised to see how relatively close together the first four planets are, crowded around the Sun. Beyond Mars, however, the planets are vastly spread out.

Expand

Ask the students who represented each planet to work with a small team of other students to figure out how large each of their planets would be, if the actual solar system were really as small as the model you just created. Use Table 1B-1, and help them make scale cross-references as necessary. As follow-up to Activity 1B, ask them to figure out the distance their planet would be from the Sun if you used planets of that size in your model.

As a math and social studies activity, using local maps, have them figure out where in your community their models would need to be, if they used this larger scale, and the planets were properly distanced from your school, which would represent the Sun. See if, as a "Science Expo," project wrap-up, or year-end activity, you could distribute planet models made by the students around your town, at the right distances in public buildings for everyone to see. Invite the press, district administration, and parents to see math, astronomy, science and art in cooperative action!

Table 1C

Planet	Miles	Kilometers	A.U.
Mercury	35,985,000	57,900,000	0.39
Venus	67,247,000	108,200,000	0.72
Earth	92,977,000	149,600,000	1.00
Mars	141,641,000	227,900,000	1.52
Jupiter	483,717,000	778,300,000	5.20
Saturn	885,954,000	1,425,500,000	9.53
Uranus	1,788,129,000	2,877,100,000	19.23
Neptune	2,801,802,000	4,508,100,000	30.14
Pluto	3,701,057,000	5,955,000,000	39.81

"Moving Targets"

The position of any object on Earth can be plotted on a map using that object's unique longitude and latitude. In the same way, celestial objects can be plotted on maps of the sky using a similar set of coordinates. Declination (Dec.) takes the place of latitude and is measured in degrees and minutes of arc north (+) or south (-) of a line in the sky called the "celestial equator," which lies directly above the equator on Earth. Astronomers use Right Ascension (R.A.) in place of longitude. Just as longitude is measured from a line on Earth called the prime meridian, so Right Ascension is measured from a line that passes through a point in the sky called the "vernal equinox." Right Ascension keeps track of how the sky overhead rotates over time during the day and night, and so Right Ascension is measured in units of time (hours and minutes). The Right Ascension and Declination of stars don't change significantly on the time scales we need to worry about for contemporary astronomy. But the planets are all moving around the Sun at different speeds in different orbits so their Right Ascensions and Declinations are always changing along with that of the Sun (since the Earth, too, is moving).

It's important for HST mission planners to keep track of the ever-changing positions of the Sun and planets in planning observing times for astronomers because for safety reasons, the HST is usually not pointed within about 45 degrees of the Sun (although sometimes with the Earth acting as a kind of shield, it can—with great care—be pointed closer). In Activity 2C, students will act as Mission Planners for the HST. They'll be asked to plot the position of the planets and the Sun, for a series of dates, and to determine which planets are safe to view on those dates, and which will appear too close to the Sun to observe safely.